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THE StressPoint™

FOR EXPERTS | BY EXPERTS

A publication of Engineering Design & Testing Corp.

AIR INFILTRATION & LEAKAGE

What is it, how can it impact energy costs and steps you can take to reduce excess costs brought on by air infiltration and leakage.

EDT CASE STUDIES

A Selection of Recent Assignments

A YEAR IN REVIEW

2019 Conference Attendance

HURRICANE FORCES:

Wind VS Wave Forces

How EDT determines the cause of damage based on hurricane wind and water forces.

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Engineering Design & Testing Corp. is an association of forensic engineers dedicated to the study, and interpretation of loss.

A Message from the President

Dear Friends,

A quote attributed to Mark Twain says "Climate is what we expect, weather is what we get." Sometimes we get more than we expect but, regardless the season, the earth experiences variations in heating and cooling each day. Hot air masses rise and cooler air masses move in creating winds. When air is entering and leaving your building, it can cause comfort and cost issues, as Michael Dickenson explains in his segment.

When air masses move slowly on a larger scale, we call it a breeze, which is beautiful in summer and fall, especially on a porch, a sail boat, or enjoying the Blue Ridge Mountains. When air masses move quickly on a larger scale, it's a wind storm. If those winds are on land and begin to spiral, it becomes a tornado. If they are over water and begin to spiral and pick up water, it's a cyclone or hurricane. As Charles Whitley describes in his piece, the speed of the winds sets the category number and generally greater damage, but the associated water from waves or surge can also cause significant damage. The ability to segregate which caused the damage is an important skill in examining losses.

If thinking about all that brings back too many bad CAT memories, then let's go where it's warm, sit on a deck (made with the correct pressure treated wood), drink a beer (a craft brew for me, please) and watch the spiders spin their stronger than steel webs. I hope you enjoy this issue of The Stress Point and the coming Holiday season.

Respectfully,

Kenneth S. Marshall

Kenneth S. Marshall, P.E.
President

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THE StressPoint™

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On the Cover: Home devastated by Hurricane Michael (wind & water damage)

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Hurricanes are somewhat unique in that they generate multiple types of forces that can affect coastal properties

This article discusses how EDT determines the cause of damage based on hurricane wind and water forces.

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THE StressPoint®
Fulcrum

> *Give me a fulcrum and a place on which to stand, and I will move the world.*
>
> *—Archimedes, Greek Inventor and Mathematician*

SPIDER SILK

ONE OF NATURE'S MOST VERSATILE MATERIALS

Spider silk is one of the toughest and most versatile materials on Earth. It is produced by silk glands and consists of proteins called "spidroins" which form a liquid crystalline solution called "dope". Within the dope, chains and other structures self-assemble, narrowing as it passes through the gland until a strand is produced as it exits the spider's spinnerets. When the spider pulls the silk from the spinnerets, it dries, becoming the fiber that we know today as spider silk.

Prehistoric spiders utilized their silk specifically for shelter construction. It has taken millions of years of evolution to perfect the ways spider silk is used by modern spiders. Uses of spider silk vary greatly as do species of spiders found throughout the world today. Transportation, catching prey, and even courtship are all ways spiders now employ this amazing material. Some spiders are even known to produce more than one type of silk. The common orb-weaver web contains at least four different kinds of silk, each type of silk meeting specific requirements for which it was produced, be it strength, flexibility, or stickiness.

By weight, spider silk is incredibly strong, stretchy, and flexible. As yucky as webs are to accidentally walk into, they tend to be very clean, possessing antimicrobial properties. Scientists have been at work attempting to produce synthetic web silk for medical applications. One day we may use synthetic spider silk to treat wounds or even to mend broken bones. However, mass-production of synthetic spider silk has yet to be achieved.

DID YOU KNOW?

Spider silk is so versatile that we could make virtually anything from it, such as bridge cables, airplane parts, and even biodegradable bottles!

IS SPIDER SILK STRONGER THAN STEEL?

Mythbusters Jr. is a television show that challenges commonly held myths. One episode was devoted to challenging the myth that "Spider silk is stronger than steel". In this episode, host Adam Savage and a cast of kids ran a series of experiments to see if this myth held true. They proceeded with experiments in which steel wire and spider silk were each used as cables to suspend a 22qt. bucket. During the experiments, they incrementally filled each bucket with water until the steel wire or silk failed.

The first was a small scale test where they used 30µm[1] of steel wire versus it's mass density equivalent of 500 strands of spider silk. The results determined spider silk to be 2x as strong as steel, which is great, but they weren't totally satisfied. Another test was to be done, but on the largest scale possible, to get the best results to bust this myth.

In the second test, they use a 28-gauge steel wire versus its mass density equivalent of 25,000 strands (or ~ 9 miles) of spider silk which had been collected from 42 spiders over a 5-week period. Now, that's a lot of web work! First up was the 28-gauge steel wire which stretched and stretched, inch by inch, until it snapped. The result? The 28-gauge wire was able to hold a bucket of water weighing in at 12.5 pounds (~5.9qt.).

Next was the 25,000 strands of spider silk, which bore the 12.5-pound bucket load while barely stretching. Quart after quart was added to the bucket suspended by the spider silk, surpassing the results of the steel wire. Suddenly, a pop was heard but the silk strand held on just a bit longer until it finally broke. The result? A length of spider silk consisting of 25,000 strands being equal in thickness to 28-gauge wire, was able to suspend a bucket weighing 26 pounds (~12qt.), proving to be just a little more than twice as strong as the steel. Two tests and two almost identical results confirmed the myth - spider silk is stronger than steel!

[1] (µm = one millionth of a meter)

THE BLUE RIDGE PARKWAY

ONE OF THE WORLD'S SCENIC ROAD TRIPS

Approximately 320 million years ago, North America and Europe collided, pushing up what we know today as the Blue Ridge Mountains. At the time of their emergence, they were among the highest mountains in the world reaching heights comparable to today's (much younger) Alps. However, due to weathering and erosion over hundreds of millions of years, the highest peak in the range, Mount Mitchell in North Carolina, sits at only 6,684 feet high, but is still the highest peak east of the Mississippi River.

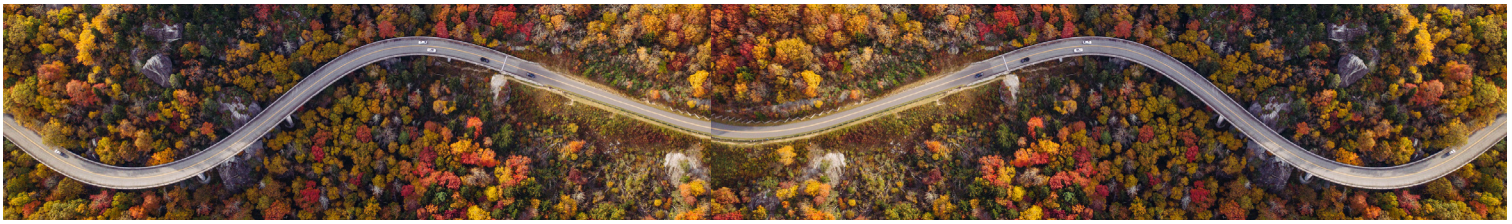
Each year, millions of visitors enjoy the Blue Ridge Parkway. It is one of the most pleasant and relaxing scenic drives in the country. But something not known to most of its visitors is that the Parkway is also filled with significant natural resources.

Of the regions that make up the Appalachian Mountain range, the Blue Ridge Mountain region contains the largest mountains in the eastern United States. The Blue Ridge region spans 550 miles southwest from southern Pennsylvania down through Virginia, the western Carolinas, eastern Tennessee, and northern Georgia. Within the Blue Ridge region are two national

parks – the Shenandoah National Park in the north and the Great Smoky Mountains National Park in the south. Located in the Blue Ridge region is the Blue Ridge Parkway, a 469-mile (755 km) long scenic highway traveling along ridge crest-lines sharing the terrain with the Appalachian Trail. The Blue Ridge Parkway connects the two parks, protecting a diversity of plants and animals, providing opportunities for visitors to enjoy everything that makes this region of the country so unique. The Parkway winds through a wide range of habitats along the Appalachian Mountains, some being exceptionally rare. Throughout the drive, visitors will encounter a diversity of climate, vegetation, wildlife and geological features that make this region world-renowned for its biodiversity.

A unique feature from which the Blue Ridge Mountains derive their name is their blue-ish color when viewed from a distance (see picture above). Trees in this region release isoprene into the atmosphere creating the range's characteristic "blue haze". What is isoprene, you ask? Well, isoprene is an organic hydrocarbon. It combines with other airborne molecules to create the distinctive coloring by altering the wavelength of sunlight. The isoprene emission is thought to have a protective effect on plants, from repelling insects to protecting against other dangers, like heating, which interfere with photosynthesis.

All-in-all, a Blue Ridge Parkway experience is unlike any other. It is a slow-paced, winding, and relaxing drive with stunning long-range vistas, close-up views of the rugged mountains, and pastoral landscapes of the Appalachian Highlands. If you ever have the chance to visit, make sure to have a full tank of gas and your camera ready!



CASE STUDIES: A SELECTION OF RECENT ASSIGNMENTS

THE FOLLOWING ARE SELECTIONS OF RECENT ASSIGNMENTS (CASE STUDIES) BY A FEW OF EDT'S ENGINEERS ACROSS THE COUNTRY.

PRESSURE TREATED WOOD (AWPA USE CATEGORIES)

By: Glenn Stewart, M.E., P.E. | Columbia District Office

When evaluating existing buildings or structures of wood construction, often structural damage from fungal-based decay or insect infestation is encountered. Provisions can be taken by the design and construction professionals to minimize this type of damage. One method to minimize the potential of decay and deterioration is by using pressure treated wood. Of course not all pressure treated wood is the same. As a result, as we go about our work of evaluating existing buildings and structures, it is important to understand what pressure treated wood is and how to select the proper type for a particular application.

Techniques for preserving wood have been employed since soon after the advent of its use. Historical techniques provided protection through the application of coatings or from limited penetration of the wood by soaking the wood in a preservative agent. Modern techniques force the preservatives farther into the wood.

In order for wood to decompose, four conditions are needed: high moisture, favorable temperature, oxygen, and a food source (wood fiber). Pressure treatment eliminates the wood fiber as a food source and removes a condition required for decomposition. During the treatment process, wood is placed in pressurized vessels where preservatives are forced deep in the wood fibers. Three broad classes of preservatives are used: water-borne preservative, oil-borne preservative, and creosote preservatives. Under each of the broad classes are different preservative systems with different chemical compositions and trade names.

Sorting through the various preservative systems and classes to select the proper piece of lumber for a project can be a complicated process. Both the International Building Code and the International Residential Code reference use of the American Wood Protection Association Standard, AWPA U1, *Use Category System: User Specification for Treated Wood*. Manufacturers often label their products with the appropriate U1-Use Category. Each U1-Use Category is suitable for different service conditions, environments, and is recommended for typical applications. For example, Use Category UC3B is intended to be used in above ground exterior construction such as railings and decks while Use Category UC4A is intended to be used in general applications with ground contact, such as a deck posts. When constructing a wooden bulkhead in a salt water marine envirnoment in Florida, Use Category UC5C is appropriate.

The use of pressure treated wood is one of the provisions available in order to minimize the potential for future decay and insect infestation of wooden structures. As we proceed with our evaluations of buildings and structures we should remember that not all pressure treated wood is the same and that AWPA U1 Use Categories are a source of information that can assist with ensuring that the proper materials have been used.

Potential resources for further research on this topic are AWPA U1-17, Use Category System: User Specification for Treated Wood and Southern Forest Products Association, Pressure Treated Southern Pine: Standard, Specifications, Applications, 2010 and 2017 Editions.

BEER MAKING & THE FAILURE OF A MASH TUN

By: Steven M. Lindholm, P.M.P., P.E. | Oakland, California District Office

WE'RE SURE MANY OF YOU OUT THERE ARE FANS OF A GOOD CRAFT BEER…

Have you ever wondered how beer is created from water, barley malt, yeast, and hops to provide that effervescent, frothy drink? As you may be aware, it hinges on fermentation. Brewers start with grist, the ground barley malt. Grist is mixed with water to become the mash, which is then pumped into a vessel called a tun, where the mash is boiled. Within the mash tun, hop flowers may be added for flavor and to help preserve the beer after fermentation. The wort, the extracted liquid from the mash is then fermented in a tank, which can either be open (especially for Belgian type ales or 'steam' beers) or closed – like a wine tank. Yeast is added at the fermentation stage to convert some of the sugars in the malted wort into alcohol and carbon dioxide – the fizzy little bubbles which add to the drinking experience. Some beers are then finished with additional 'dry' hops during the fermentation process.

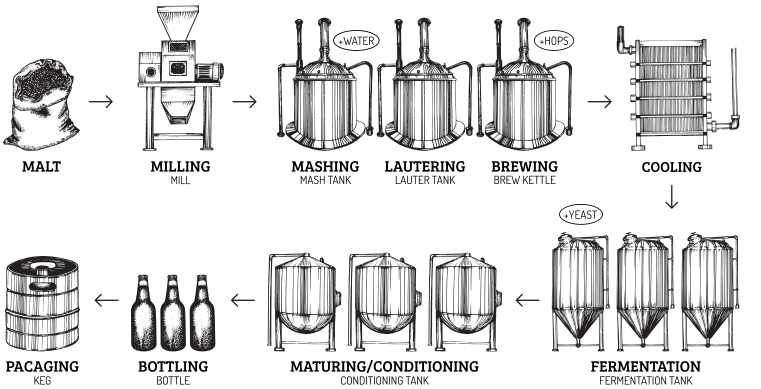


Figure 1 - Mash Tun

The mash tun is an important component in this process. The mash tun brings the mash to a boil, which sterilizes the wort and continues to break down some of the complex starches into sugars the yeast can digest. While the tun is heated to boil the mash, the mash is also stirred for homogenous heating and, if hops have been added, to impart the hop oils into the mash.

Figure 2 - Indent on Mash Tun

At a local craft brewery, EDT was called to investigate why one of their mash tuns failed. The mash tun in question was a newly constructed tun with integral mixing paddles suspended from the top dome, an upper cooling water jacket, and a lower boiling water jacket. Examination of the interior of the tun revealed the upper cooling jacket had collapsed into the tun, most pronounced at the two locations where the bearing for the mixing paddle shaft was supported. Examination of the mixing paddle assembly revealed the bearing was jammed off-axis and the shaft had fractured in the weld at the motor keyway (see all figures).

Analysis of the incident led to the conclusion that the support of the paddle shaft bearing was insufficient, allowing radial movement of the paddle assembly in the tun. After a short time, the bearing locked up off-center, pulling on the walls of the cooling jacket until they collapsed into the tun and the shaft weld fractured. The root cause of the failure was insufficient support of the shaft bearing – two points of connection where three or more would provide full stability.

Figure 3 - Fractured Shaft Keway

Figure 4 - Offset Paddle Shaft Bearing

Two lessons could be learned from this failure – one for the brewery and one for the manufacturer. The brewery to ask for the operational history of the tuns they purchase; the manufacturer to realize the importance of fully stabilizing rotating shafts.

HURRICANE FORCES: WIND vs WAVES

By: Charles E. Whitley, P.E.

Over the past 15 years, the United States has dealt with the landfall of numerous major hurricanes. While Hurricane Katrina and Superstorm Sandy are the first two storms that most people remember, additional Category 4 or 5 hurricanes that have made landfall in the United States since 2004 include Charlie (2004), Harvey (2017), Irma (2017), and Michael (2018). During this same period of time, five Category 3 hurricanes made landfall in the United States. While there are multiple hazardous weather conditions associated with the landfall of a major hurricane, the two conditions that typically result in the majority of damage during landfall are high winds and the storm surge.

High winds are typically the first thing people think of when they hear about an approaching hurricane. Hurricanes start as a tropical cyclone. According to the National Oceanic and Atmospheric Administration (NOAA), "A tropical cyclone is a generic term for a low-pressure system that formed over tropical waters (25° S to 25° N) with thunderstorm activity near the center of its closed, cyclonic winds." NASA says that "Tropical cyclones are like giant engines that use warm, moist air as fuel…The warm, moist air over the ocean rises upward from near the surface. Because this air moves up and away from the surface, there is less air left near the surface. Another way to say the same thing is that the warm air rises, causing an area of lower air pressure below and as the warm air continues to rise, the surrounding air swirls in to take its place. The whole system of clouds and wind spins and grows, fed by the ocean's heat and water evaporating from the surface."

As more heat is added from the warm ocean waters, the cyclone continues to grow until a hurricane is formed. Depending on the environmental conditions that the hurricane encounters, hurricane force winds vary from 74 miles per hour (MPH) to greater than 157 MPH.

In addition to high winds, most major hurricanes also produce a large storm surge. Storm surge, according to NOAA, is "produced by water being pushed toward the shore by the force of the winds moving cyclonically around the storm. The maximum potential storm surge for a particular location depends on a number of different factors. Storm surge is a very complex phenomenon because it is sensitive to the slightest changes in storm intensity, forward speed, size (radius of maximum winds – RMW), angle of approach to the coast, central pressure (minimum contribution in comparison to the wind), and the shape and characteristics of coastal features such as bays and estuaries." The flow of water pushed inland by hurricane force winds can result in significant damage to coastal structures. Wind created waves can add to the damage. NOAA states, "Adding to the destructive power of surge, battering waves may increase damage to buildings directly along the coast. Water weighs approximately 1,700 pounds per cubic yard; extended pounding by frequent waves can demolish any structure not specifically designed to withstand such forces. The two elements work together to increase the impact on land because the surge makes it possible for waves to extend inland."

HURRICANE FORCES BY THE NUMBERS

When a coastal property is subjected to both high winds and storm surge, determining what damage was caused by the winds versus what damage was caused by the surge and waves can be difficult, as both high winds and storm surge can result in similar damage. The loss of exterior claddings, structural deformations, and other damages can result from the forces generated by both winds and storm surge. In addition, coastal structures are subject to the forces generated by both high winds and storm surge at the same time, increasing the difficulty in separating the damages resulting from each.

The forces applied by high winds and storm surge to a structure are similar. For an analysis of the forces, both wind and storm surge are considered to result in the flow of a fluid past a static body. The impact of the fluid with the structure, and the interaction between the fluid and the structure, results in forces being applied to the structure. For winds, the fluid that is flowing is air. For a storm surge, the fluid is water. In both cases, the structure is considered to be a static, or non-moving, body. The calculations required to determine the forces depend on the mass of the fluid, either air or water, the velocity of the fluid, the shape of the structure, and the surface area of the structure. For a structure, the shape and size do not change, which means that the mass of the fluid and the speed of the fluid are the most significant variables. For a Category 4 hurricane, wind speeds are a minimum of 130 miles per hour (MPH). FEMA has estimated that in a 130 MPH wind, the top portion of the storm surge coming ashore has a speed of 7.6 feet/second, or 5.2 MPH. Other estimates of the speed of the surge are higher.

A comparison of these two numbers shows that the air is hitting the structure at a speed that is 25 times greater than the speed of the water that is hitting the structure (130/5.2 = 25). At 75 degrees, air has a mass of 0.074 pounds per cubic foot, while water has a mass of 62.4 pounds per cubic foot, or 843 times greater than the mass of air (62.4/0.074 = 843). Therefore, while the air is striking a structure at a speed that is 25 time faster than the water, the mass of the water is 843 times greater than the mass of the air. For a comparison, think about the last time you stood knee deep in the ocean. The wind hitting you is moving much faster than the water that is hitting you, and is hitting a much larger percentage of your body, but creates only a fraction of the force of that created by the impact of the water. When standing in the ocean, a far greater number of people have been knocked over by waves than have been knocked over by wind. Calculations have shown that forces applied to a structure by storm surge are typically much higher than the forces applied by high winds. The forces resulting from the battering of waves should also be considered when comparing wind-related forces to water-related forces.

SEPARATING WIND DAMAGE FROM WAVE DAMAGE

Although both wind generated forces and storm surge generated forces result in similar damage to coastal structures, there are methods that can be used to separate the damage caused by each. The first step in determining what damage was caused by wind versus what damage was caused by storm surge is often determining the level of storm surge that a structure was subjected to. For structures that were not demolished during the landfall of a hurricane, there are often high water lines left behind as the storm surge recedes. If a definitive water line can be identified, simple measurements can be made to determine the maximum level of surge that the structure was subjected to. For structures that were demolished during the landfall, water lines can sometimes be found on nearby intact structures. If there were no barriers to prevent the inland flow of the surge, the elevation of the point at which the surge stopped and began to recede can be determined, although there are multiple variables that can affect the amount of inland flow. After the landfall of most hurricanes, FEMA and other government agencies will publish data on the extend and elevation of the storm surge. This data is often not available until several months after the landfall.

Once the level of storm surge effecting a structure has been determined, the next step is to determine the maximum wind speed that the structure was subjected to. As with the storm surge, there are multiple government agencies that publish wind speeds for various coastal locations. The data on wind speeds is often available before the storm surge data is published. There are also numerous commercial agencies that will provide weather-related data associated with a hurricane.

With both wind speeds and storm surge levels in hand, an analysis of the forces applied to the structure can be made. The area exposed to winds can be determined, along with the area exposed to the storm surge. Before the storm surge comes ashore, the entire structure is exposed to winds, although the wind speeds are typically lower than those experienced at the time of the peak storm surge. As the surge comes ashore, the area of the structure exposed to the surge increases while the area exposed to wind decreases as the water level around the structure rises, partially submerging the structure. With the wind speed and the area of the structure exposed to winds and surge both changing during landfall, calculations of the forces should be made at multiple points in time to account for the variations. It

is often helpful to chart the forces against time in order to determine the peak wind force and the peak surge force, and to determine when they occurred.

With high winds effecting structures before they are affected by the storm surge, it is often necessary to determine if a structure was damaged by the winds before the surge arrived. If wind damage preceded the arrival of the surge, it becomes necessary to determine the amount of such damage. For structures that were demolished, the amount of evidence available from the structure in question is limited. In such cases, an examination of the surrounding, intact structures can provide helpful information.

Fig. 1 - Location of railroad relative to coastline

For example, a railroad on an elevated berm extends along a large portion of the Mississippi coast (Figure 1). In many areas, the berm acted as a dam and stopped the inland flow of the storm surge from Hurricane Katrina. With the surge stopping at the railroad, structures south of the railroad were subjected to surge-related forces, while structures north of the railroad were not. Structures on either side of the railroad were subjected to equal wind forces.

Fig. 2 - Scope of damage North of railroad

For structures of similar construction, a review of the wind-related damage to the structures north of the railroad (Figure 2) provided an indication of the type and amount of wind-related damage that the structures south of the railroad would have experienced.

Fig. 3 - Scope of damage South of railroad

In many cases, structures south of the railroad (Figure 3) were demolished by the hurricane, while similar structures north of the railroad experienced only cosmetic damage. With structures both north and south of the railroad subjected to equal wind speeds, the only condition that could have resulted in the demolition of the structures south of the railroad was the storm surge.

Similar conditions can be found in locations that do not have a physical barrier such as an elevated railroad. Modern wood-framed coastal structures are typically supported on pilings, to elevate the main portion of the structure above potential storm surge levels. When the surge does not reach the elevation of the floor framing, surge-related damage is typically minimal, as the surge forces act only on the pilings.

When piling supported structures near the shoreline have been destroyed, an examination of intact piling supported structures further away from the shoreline can be made to determine the maximum elevation of the surge. Waterlines left on the intact structures can show how high the surge reached on the structure. Using this information, it is possible to determine if the surge elevation exceeded the elevation of the floor of the structures that were destroyed, and if so, how high above the floor the surge extended. With this information in hand, the calculations discussed above can be made to determine the magnitude of both the wind and surge forces applied to the structure.

Other information that can be used in determining the cause of damage to structures includes the direction and distance that debris from the structure was transported, the presence of other structures that would have provided protection for the structure in question, and the quality and type of construction of the structure in question.

In cases where the surge and waves extended above the elevation of the floor framing, surge-related forces are often significantly higher than wind-related forces, with the surge-related forces sufficient to result in the demolition of the structure, while the wind-related forces may not be. In such cases, the amount of wind damage that occurred prior to the arrival of the surge must be determined, as both wind and surge-related damage would have occurred.

With multiple possible causes of damage to structures occurring during the landfall of a hurricane, damage evaluations after landfall can be a challenge to a forensic engineer. However, with a complete understanding of the weather conditions that occur and how those conditions effect structures, an accurate determination of the cause and scope of damage to structures in coastal regions can be made by an engineer willing to do the work, both in the field and behind the desk.

Railroad destroyed by Hurricane Katrina

ABOUT THE AUTHOR

CHARLES E. WHITLEY, P.E.

Birmingham District Office | Birmingham, Alabama

Mr. Whitley is a civil/structural consulting engineer in Birmingham, Alabama. He also serves as the Chief Engineer. Mr. Whitley provides consultation related to the design and construction of industrial, commercial, and residential structures; failure analysis; damage assessment; and expert testimony. Over the years, he has worked on a wide range of industrial and commercial projects including construction defect inspections, litigation support, and numerous other types of work.

Recent projects include work to determine the cause and scope of damage to a collapsed parking deck in south Florida, a review of the design and construction of a marine research facility in South Carolina with numerous reported design and construction defects, and the analysis of both the design and construction of an automobile manufacturing facility in Alabama that was experiencing excessive settlement.

Mr. Whitley has experience in storm-related damage assessment, including wind versus flood water evaluations. He has analyzed hurricane and tornado-related damages to various types of structures throughout the Southeast.

Prior to joining EDT in 1999, Mr. Whitley performed civil/structural design and construction management work on projects with the pulp and paper industry and the chemical production industry. He is a graduate of the University of Alabama at Birmingham.

STATE LICENSES:
Mr. Whitley is a licensed engineer in the following states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Tennessee.

AIR INFILTRATION & LEAKAGE

By: Michael W. Dickenson, P.E., CFEI, CFVI

AIR INFILTRATION AND LEAKAGE – MONEY SAVING SOLUTIONS FOR HOMES AND BUSINESSES

Although addressing air infiltration and leakage is critical throughout the year, it is especially important to address before winter arrives. In this article, we will discuss air infiltration and leakage, what they are, and how they can impact energy costs. We will also point out simple steps that home and business owners can take to reduce the excess costs brought on by air infiltration and leakage.

WHAT ARE AIR INFILTRATION AND LEAKAGE?

Air infiltration and leakage occur when unfiltered, unconditioned air passes through a structure's "building envelope" via cracks, damaged seals, or improperly sealed building penetrations.

Specifically, air infiltration refers to the quantity of unconditioned air (typically from the outdoors) entering/seeping into the interior space; where air leakage refers to conditioned air lost/leaking out of the interior space to the outdoors.

When infiltration and leakage occur, the air must pass through the building envelope. The building envelope is the space separating interior, conditioned spaces (such as living rooms and bedrooms in residential construction, or offices and meeting rooms in commercial construction) from outside/unconditioned spaces.

WHY SHOULD HOME AND BUSINESS OWNERS CARE ABOUT AIR INFILTRATION AND LEAKAGE?

Air infiltration and leakage impact heating, ventilation, and air conditioning (HVAC) system(s) in negative, costly ways because they force HVAC units to have higher-than-average run times. Essentially, the longer an HVAC system runs, the potential for increased wear, coupled with the increased energy used, results in higher costs. Unfortunately, due to the nature of the problem, air infiltration and leakage are not easily recognized and could go unnoticed – and unaddressed. This is problematic in more ways than one.

For home and business owners alike, air infiltration and leakage result in increased energy usage as the HVAC system tries to condition air from the outside.

> "For home and business owners alike, air infiltration and leakage result in increased energy usage as the HVAC system tries to condition air from the outside."

WHERE DO AIR INFILTRATION AND LEAKAGE OCCUR?

Common areas where air infiltration or leakage occur are window seals, chimneys, bathroom exhaust fans, and their ductwork, or at wiring penetrations. Due to pressure differences between the conditioned space and the outdoors, it is common for air to infiltrate through cracks within the building envelope on lower levels, basements, and crawlspaces. Conversely, it is common for air leakage to take place with higher levels, including chimneys, upper floors, or at cracks between the attic and conditioned spaces. (Fun fact: the driving force for air infiltrating at lower levels coupled with air leaking at upper levels is a phenomenon known as the stack effect, a discussion for a later.)

If buildings/homes have considerable air infiltration or leakage, it can be indicative of a larger issue and trained professionals should be consulted.

> If buildings/homes have considerable air infiltration or leakage, it can be indicative of a larger issue and trained professionals should be consulted.

HOW CAN HOME AND BUSINESS OWNERS LOWER ENERGY COSTS BY REDUCING AIR INFILTRATION/ LEAKAGE?

Simply put, reducing air infiltration and/or leakage results in reduced energy costs (and potential tax credits or incentives). Here are some steps home or business owners may take to minimize air infiltration and leakage:

- Apply foam sealant, as directed, to areas where air movement can be felt.
- Examine and replace deteriorated exterior door seals and thresholds.
- Ensure windows are locked and window seals are intact. (Consult with a professional to replace or repair window seals and parts).
- Minimize opening/closing exterior doors during extreme winter temperatures.
- Within the crawlspace/basement, seal gaps around supply-air ductwork and floor connections.
- Examine bathroom exhaust fans, replacing backdraft dampers, if needed, and sealing gaps/spaces around the exhaust fan housing.

HIGH ENERGY BILLS? UNDERSTAND AND IMPROVE ENERGY PERFORMANCE: AIR CHANGES PER HOUR

Air infiltration (air that comes in) and air leakage (air that goes out) negatively impact energy usage and costs in conditioned spaces – for homes and businesses alike. We've talked about what infiltration and leakage are and how to combat them at a basic level, but to really fix the problem for the long term requires measuring and improving your building's Air Changes per Hour, or "ACH."

CAN AIR INFILTRATION AND LEAKAGE BE MEASURED?

The quantity of air which is exchanged between the indoor (conditioned) space and the outdoor (unconditioned) space can be determined by a blower door test. Professionals perform a blower door test by using a fan, usually located at the front door, to pressurize the building envelope. Controls which are connected to the fan are used to measure pressure difference between the indoor and outdoor conditions.

The test results in a number for air exchanged between the indoor air to the outdoor air, referred to as air changes per hour (ACH).

WHAT DOES AN ACH NUMBER MEAN?

ACH ranges between zero and ten. In general, ACH below two is correlated with air-tight construction and is the ideal state for maximum energy efficiency and heating, ventilation, and air conditioning (HVAC) unit effectiveness. Common residential construction ranges between 2 ACH and 4 ACH; ACH values greater than 5 ACH should be evaluated.

EXAMPLE: For the sake of differentiating the cost between what would be considered "air-tight" construction and "leaky" construction, some assumptions are made:

- One-week time period
- Winter with outdoor temperatures averaging 20 degrees Fahrenheit
- "Leaky" and "air-tight" constructions are heated with all electric heating
- Target indoor temperature (setpoint) is no less than 60 degrees
- Each construction contains 1200 square feet of conditioned space
- Average electric utility charge is $0.09 per kilowatt-hour (KWH)
- "Leaky" construction results in $160.73 additional heating costs from air infiltration/leakage
- "Tight" construction results in $45.46 additional heating costs from air infiltration/leakage

HOW CAN ACH NUMBERS BE IMPROVED TO REDUCE ENERGY WASTE/COSTS?

Here are some steps home or business owners may take to accomplish better energy effectiveness and realize a cost savings by improving ACH:

- Foam sealant can be purchased at most hardware stores and is sold in pressurized cans. Applying the sealant, as

directed, to areas where air can be felt entering or exiting the building will reduce air infiltration and leakage. One example where applying foam sealant can have a positive effect is relating to conductors and bore holes within a crawlspace. A home or business owner can seal the annular space around the conductor to prevent air movement within the bore hole. Piping penetrations of a building envelope should be sealed in a similar manner.

- Examine and replace exterior door seals and thresholds which have deteriorated. Ensure the new seals provide an air-tight seal when the door is shut, and that no air movement is felt around the door jamb.
- Ensure windows are locked, and the seals prevent air movement around exterior windows. If air movement is felt with a window seal, consult the window manufacturer regarding the proper procedure to replace a seal.
- If floor registers are used, verify no air movement exists between the supply air ductwork and the floor opening. If air movement is felt, sealing gaps around the supply air ductwork floor connection is recommended from the crawlspace/basement.
- Examine bathroom exhaust fans. If air movement is felt at the center of the decorative grille, air may be leaking past the backdraft damper and the damper should be examined/replaced. If air movement is felt around the edge of the decorative grille, the grille may need to be removed to seal gaps/spaces around the exhaust fan housing.

> **Local utility providers or government institutions may provide assistance to home or business owners, such as tax rebates or other incentives, when steps are taken to reduce energy waste, such as those discussed in this article.**

WHAT IS THE REAL IMPORTANCE OF ACH?

ACH is really an indicator of a home or building's overall energy performance, related to its HVAC:

- If ACH is low, costs and energy consumption are lower.
- If ACH is high, costs and energy consumption are higher. Furthermore, machine/equipment lifespans are dramatically reduced.

In short, whether your home or business has noticed increased energy costs, poorly functioning HVAC units, or a home/business owner simply wants to improve energy efficiency and system effectiveness, there are steps you can take to improve ACH. Primarily, home and business owners can reduce energy costs related to air infiltration and leakage by sealing gaps and cracks where these problems occur. However, it's also important to recognize where at-home-fixes end and professional-expertise begins. Remember to contact manufacturers and experts when it comes to working safely with equipment and products. Getting the job done right (and, again, getting the job done safely) is the best way to ensure long equipment life, improved energy costs, and more sustainable energy consumption.

NOTE: Do not attempt any of the suggested tips with which you are not comfortable. In some cases, a trained, licensed contractor may be required. Safety is paramount when dealing with electrical wiring or other potentially hazardous systems and materials.

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Mr. Dickenson has always been fascinated with machinery and heavy equipment, even working for Caterpillar before attending college. As an undergraduate, he participated in an internship at Oak Ridge Lab where he was exposed to new building technologies and HVAC designs. Mr. Dickenson earned a bachelor's degree in mechanical engineering from Tennessee Tech University with an emphasis on HVAC, thermodynamics, and fluids. Prior to joining EDT, he worked in a mechanical and plumbing design firm providing construction documents for projects such as commercial offices, restaurants, and multi-family housing.

He provides technical consultation and analysis on commercial, industrial, and residential incidents involving mechanical and heavy equipment. His services include origin and cause, failure analysis, damage assessment, interpretation of codes and standards, and evaluation of fire and explosion origin and cause.

When not at work, Mr. Dickenson spends his time with his wife on their farm. He enjoys rebuilding tractors and equipment of all sizes, as well as home improvement projects.

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A Year in Review...

EDT 2019 CONFERENCE ATTENDANCE

By: Charles W. Jackson, MBA, Director of Business Development

CHARLES W. JACKSON, MBA
Director of Business Development

2019 has been a very busy year for EDT. I didn't think it would be possible to top how busy we were in 2018, but we did it. In total, we have participated in 23 events this year. We added three new events in 2019, including the St Louis Claim Managers' Council Golf Tournament and two marine events - the Inland Marine Conference in St. Louis, MO and the International Workboat Show in New Orleans.

In 2019, a handful of our engineers presented at the PLRB Regional conferences in Minneapolis, MN, and Charlotte, NC, the Combined Claims of Northern California in Squaw Valley, CA, the NAIIA Western in Las Vegas, NV, and the Annual NASP Conference in Washington, D.C. We hope to present at even more conferences in 2020!

I am often asked which of the events is my favorite. Each event is very different. My favorites tend to be those put on by the NAIIA. There are a lot more opportunities for relationship building at NAIIA events and the organization is so appreciative of our sponsorship. Regarding my favorite event of 2019, that would have to be the Greater Kansas City Claims Association Golf Tournament, mainly because of the assistance I had this year. My 15-year-old daughter Emily made the trip with me so she could see what I do. Emily was great with our clients and I hope she will attend annually from now on.

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LONG STORY SHORT

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